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Developing engineers who lead: Are student, faculty and administrator perspectives aligned?

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Introduction

As society becomes increasingly globalized and technologically advanced, the need for leaders with technical expertise to link technology and policy for sound, sustainable policy decisions continues to rise. Preparing the next generation of engineers to serve in societal leadership roles is imperative if the United States is to maintain its global technological and financial edge; this claim is well documented by engineering educators, practitioners, and the Department of Defense[1-5].

The National Academy of Engineering (NAE) [3] has called for a refinement to the education of future engineers, setting a goal for having them more broadly educated and preparing them to "be leaders in business and public service." [3] This call for more well-rounded engineers is necessary to facilitate their preparation to serve in substantial leadership roles so that they can help drive initiatives for developing technological solutions to—and policy decisions for—global problems in our increasingly technology pervasive society. Emphasized by ABET [6], engineers are charged with understanding the global, economic, ethical, and societal impacts of their technical decisions. Policy decisions in our dynamic, technical society require this firm understanding of the limits and effects of science and technology [3]. To accomplish this goal, the NAE cites the need for engineers to understand the principles of leadership and apply them throughout their careers. [3]

As the world's technical expertise continues to globalize, leadership is also important for an individual's professional success in industry. [7] Countries such as China and India continue to outpace the U.S. in production of STEM graduates. [1; 5; 8] Because globalization increases access to less expensive technologically adept labor markets, [8] leadership—and professional skills in general—is one skill that can increase the competitiveness and marketability of U.S. engineering graduates. [9] Currently, a U.S. company can hire at least five engineers from India for the cost of one in the U.S.[8] By demonstrating the ability to ***lead*** international and interdisciplinary teams of technical engineers, U.S. engineers can continue to remain at the forefront of industry development and set themselves apart from competitors in the labor market. To punctuate the importance of leadership from among the greater pool of professional skills, Russell and Yao [10] summarize, "an engineer is hired for her or his technical skills, fired for poor people skills, and promoted for leadership and management skills." [10] Gerhart, Carpenter, Grunow, and Hayes [11] exemplify this perspective in describing the lack of upward progression by Lawrence Tech graduates as the motivation for starting Lawrence Tech's 4-year leadership curriculum for all undergraduate students.

Because leadership has been identified as an important skill for successful engineers, the purpose of our study is to investigate undergraduate engineers' leadership development. Moreover, we seek to characterize the degree of alignment on views of leadership across different stakeholders related to undergraduate engineering. As supported by Terenzini and Reason's [12; 13] College Impacts Framework, incorporating a comprehensive set of variables that encapsulate both organizational and students' perspectives is essential to understand how student outcomes, such as leadership, may be developed during the undergraduate experience. We draw on a nationally representative data set that includes participants from 31 institutions and 120 undergraduate engineering programs. For this study, we merge data collected from several stakeholder groups, including undergraduate students (n=5,249), faculty (n=1,119), program chairs (n=86), associate deans (n=29), and alumni (n=1,403).

Review of Literature

Within the context of engineering education, recent studies of leadership development for undergraduate engineers suggest that faculty and programs are aware of the need for leadership development. ABET accreditation criteria require programs to consider students' abilities to function on multidisciplinary teams, and leadership is specifically mentioned as a requirement for civil engineering, engineering management, and construction [6]. If and when leadership is considered in an institution's engineering curriculum, it is often in response to a combination of ABET's teaming requirements and an expressed need from alumni practicing in industry [11; 14].

Because of the technical curriculum requirements for students, however, faculty and programs disagree on the best method for implementation [15-17] or ignore its development.[7] A small number of colleges and universities have developed programs that include leadership in their curriculum e.g. [11; 14; 18]; in their comparison of the Robe Leadership Institute Model to other leadership program models, Bayless, Mitchell, & Robe [19] identified seven other programs that did so. These examples are only a small fraction of the 300-plus ABET accredited engineering colleges and universities across the United States. Small sample qualitative studies of faculty have shown that faculty perceive leadership development as a by-product of student in-class teaming experiences, co-curricular activities e.g. [15; 16] or deferred for continuing alumni education opportunities. [20]

This disagreement may be justified because of evidence that engineering faculty lack clear perceptions of the often nebulous topic of leadership.[14; 20; 21] This lack of clarity is understandable due to the subjective nature of *leadership*; although leadership is a mature discipline of study, even leadership scholars find it difficult to converge on a single definition of leadership. As Stogdill [22] describes, "there are almost as many definitions of leadership as there are persons who have attempted to define the concept."

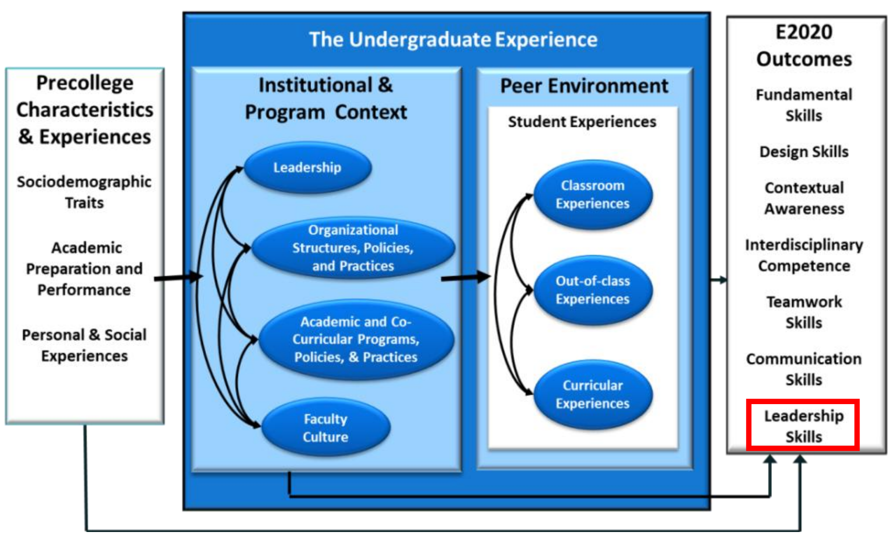
Leadership scholars have repeatedly linked work-team success to leadership. Yukl [23], in his discussion of processes affecting team performance, states that, "leaders can improve team performance by influencing these processes in a positive way." [23] Hill [24] summarizes current work in team leadership research and finds, "the totality of research supports this assertion; team leadership is critical to achieving both affective and behaviorally based team outcomes." [24] In the development of their integrative team effectiveness framework, Salas et al. [25] assert that leadership plays a central role over the lifespan of the team, claiming that despite the complexities of team leadership, "most would agree that team leaders and the leadership processes that they enact are essential to promoting team performance, adaptation, and effectiveness." [25] Additionally, Salas et al. [25] assert that team leaders play an essential role due to their synchronization of task and development cycles and for their ability to set conditions for task cycles. Even though this link between leadership and team performance is described repeatedly in industrial organizational psychology literature, Borrego, Karlin, McNair, and Beddoes [26] contend that engineering faculty are not well enough informed by industrial and organizational psychology literature to draw lessons from this body of knowledge. In their comprehensive review of 104 engineering education publications on team effectiveness, only seven articles showed leadership as a positive outcome of the teaming experience, and those seven did not advocate leadership as a strong method for increasing team performance.[26]

In summary, perceptions of leadership's place within the engineering curriculum and pedagogy have been largely based on small sample, qualitative study. Although rich in description, these studies do not facilitate generalization[27] across the larger population of engineering education practitioners within the United States. A larger study to identify the totality of the issue is warranted based on the academy's call for increased leadership from engineers—our study fills this void in the literature.

Organizing Conceptual Framework

Pascarella and Terenzini [28; 29] demonstrated through a review of several decades of higher education research that a student's content acquisition and higher-order thinking skills, among many other outcomes, are enhanced by experiences during their college years. The "college impacts" framework by Terenzini and Reason [12; 13] brings coherence to that research and conceptually combines factors forming the "Undergraduate Experience" in an effort to explain student learning outcomes and persistence. Several research studies in higher education (e.g.[30-32]), including ones grounded within an engineering context (e.g.,[33]), empirically support the framework.

Figure 1. Organizing college impacts framework for the "Engineering of 2020" learning outcomes, which includes leadership skills (revised from Terenzini & Reason[12; 13]).



Our study used a revised version of the framework, which was modified in light of empirical findings from two engineering-focused studies (Figure 1), to organize data collection and variable identification. In general, Terenzini and Reason's model hypothesizes that students' pre-college characteristics shape their engagement with various aspects of their institutions and also, to a lesser extent, have an influence on outcomes. A variety of curricular (e.g., general education coursework, major coursework), classroom, and out-of-class experiences are ways in which students engage during college. What differentiates this model from other models that link educational environments to learning outcomes is the inclusion of the institutional and program context, which includes internal organizational characteristics, structures, practices, policies, and faculty cultures. The model posits that such contexts have a direct influence on the experiences students encounter and an indirect influence on outcomes, such as leadership.

This paper focuses on investigating the institutional and program context aspect of the framework so we can better understand how stakeholders within undergraduate engineering perceive leadership. Future research will operationalize the students' pre-college characteristics and student experience components to produce a comprehensive understanding of the development of engineering undergraduates' leadership skills.

Data and Methods

Data for this study were drawn from a National Science Foundation funded project entitled the *Prototype to Production: Conditions and Processes for Educating the Engineer of 2020* (EEC-0550608) that sought to benchmark undergraduate engineering vis-à-vis its progress toward developing the National Academy's vision for the engineers of 2020. The study collected data from engineering undergraduates and alumni (three years post-graduation), faculty members, program chairs, and associate deans in a nationally representative sample of 31 colleges and universities (see Table 1). Education and engineering researchers developed the survey-based instruments for each of these populations through a two-year process. Literature reviews resulted in a survey bank of over 1,000 items, and interviews, focus groups, and pilot testing with administrators, faculty and students on multiple campuses (Penn State-University Park and Penn State-Altoona, n=482) ensured that survey items would be interpreted as anticipated by the research team. Survey items were adjusted following these tests to enhance construct validity.

Table 1: Institutional sample for the quantitative analysis.

Research Institutions:	**Master's/Special Institutions:**
Arizona State University (Main & Polytechnic)	California Polytechnic State University
Brigham Young University	California State University, Long Beach
Case Western Reserve University	Manhattan College
Colorado School of Mines	Mercer University
Dartmouth College	Rose-Hulman Institute of Technology
Johns Hopkins University	University of South Alabama
Massachusetts Institute of Technology	
Morgan State University	
New Jersey Institute of Technology	**Baccalaureate Institutions:**
North Carolina A&T	Harvey Mudd College
Purdue University	Lafayette College
Stony Brook University	Milwaukee School of Engineering
University of Illinois at Urbana-Champaign	Ohio Northern University
University of Michigan	Penn State Erie, The Behrend College
University of New Mexico	West Virginia University Institute of Technology
University of Texas, El Paso	
University of Toledo	
Virginia Polytechnic Institute and State University	

ASEE's database was used in drawing this study's sampling framework, using institution- and program-level information for the 2007-08 academic year for enrolled students and faculty. The sampling is disproportionate, semi-random, 6x3x2 stratified with the following strata: six engineering disciplines (biomedical/bioengineering, chemical, civil, electrical, industrial, and mechanical); three levels of highest degree offered (bachelor's, master's, doctorate); and two levels of institutional control (public and private). We "pre-seeded" the sample with five case study institutions from a companion qualitative study. Because one of these institutions offers only a general engineering degree, three institutions that offer general engineering degrees were included in the sample to serve as comparisons. Together, these seven disciplines (i.e., six from the sampling frame plus general engineering) accounted for 70% of all baccalaureate engineering degrees awarded in 2008. A University Survey Research Center selected 23 additional institutions at random from the population within the sampling framework.

A University Survey Research Center was responsible for data collection through a web-based questionnaire. Table 2 displays the sample sizes and response rates for each of the surveyed populations. Though a 16% response rate was lower than what we anticipated for students, response rates around the country have been declining,[34; 35] perhaps because of increased use of surveys in general through web-based forms. [36; 37] Steps were taken to account for differences between the sample of responses and the overall population by weighting cases[38] for gender, race/ethnicity, institutional response rate, and discipline. Students were also rated according to class standing, and faculty were weighted for their faculty rank. Missing data were imputed in accordance with social science research norms to reduce the number of lost cases and avoided several forms of bias that other procedures introduce e.g.[39], following procedures supported by Dempster, Laird, and Rubin[40] and Graham[41] using the Expectation-Maximization (EM) algorithm of the Statistical Package for the Social Sciences (SPSS) software (v.18).

Table 2. P2P response rates by survey type.

	Surveys Sent	Respondents	Response Rate
Associate Deans	32	29	91%
Program Chairs	125	86	69%
Faculty	2,942	1,119	38%
4-year Students	32,737	5,249	16%
Alumni	7,307	1,403	19%

Variables and Analyses

Three questions on our faculty, program chair, and administrator surveys related to professional skills—and leadership more specifically—on a broad level. Two of these asked about their perceptions of undergraduate engineering:

Do you agree or disagree with the following statements about <u>undergraduate engineering?</u>

1. Emphasizing professional skills takes time away from teaching technical content.
2. Students' leadership skills are best developed in extracurricular activities.

One related question asked these same individuals to report on the undergraduate engineering curriculum:

Do you agree or disagree with the following statements that the <u>undergraduate engineering curriculum</u> should:

3. Prepare students to assume community leadership roles.

Table 3. Characteristics of the sample (unweighted data)

Characteristic	Students [a] n=5,249	Alumni [b] n=1,403	Faculty [c] n=1,119	Program Chair n=86	Associate Dean n=29
Discipline					
Biomedical	8.5%	5.6%	6.3%	5.8%	3.8%
Chemical	13.4	12.2	11.3	14.0	7.7
Civil	17.1	16.5	17.2	20.9	11.5
Electrical	17.4	22.5	43.2	19.8	23.1
General	4.0	2.5	4.7	1.2	0.0
Industrial	4.1	7.3	6.3	11.6	11.5
Mechanical	32.2	31.3	7.3	22.1	15.4
Other	3.2	2.1	3.8	4.7	26.9
Gender					
Male	72.8%	73.7%	85.0%	87.2%	82.8%
Female	27.2	26.3	15.0	12.8	17.2
Race/Ethnicity					
African American	2.8%	2.9%	2.2%	1.2%	10.3%
Asian or Pacific Islander	8.1	6.9	9.1	10.5	10.3
Hispanic	5.8	4.3	2.1	4.7	3.4
American Indian/Alaskan Native	0.2	0.1	0.1	0.0	0.0
Other*	12.8	8.7	19.3	17.4	13.8
Foreign	5.9	2.4	12.0	1.2	0.0
Caucasian	64.4	74.7	55.1	65.1	62.1
Level					
First-year	2.3%				
Sophomore	17.1				
Junior	34.5				
Senior	46.1				
Fixed-Term			11.8%		
Assistant			22.1		
Associate			23.4		
Full			42.7		

[a] Weighted by discipline, class standing, gender, race/ethnicity, institutional response rate
[b] Weighted by discipline, gender, race/ethnicity, institutional response rate
[e] Weighted by discipline, gender, race/ethnicity, faculty rank, institutional response rate
[*] Other category includes Naturalized citizen, Middle East, Multirace, and Other category.

We compare responses to these questions across the surveyed populations. For faculty members, we parse out responses by faculty rank and status (i.e., non-tenure track instructors, assistant professors, associate professors, full professors). We also compare responses to these questions across the disciplines represented in our sample. To determine whether or not differences between disciplines are statistically significant, we conduct an analysis of variance (ANOVA) with a Bonferroni post-hoc analysis.

Students, alumni, and program chairs were asked to discuss their undergraduate program's curricular emphases on a variety of topics, two of which were related to leadership and project management. Faculty were asked to report on a course they most regularly teach, as follows:

How much does your course/program emphasize:

- Leadership skills.
- Project management skills.

For each of these variables we make comparisons across stakeholder groups and parse out faculty members by their tenure status and rank. In addition, alumni (three years post-graduation) were asked how to report on the importance of those skills in their current jobs:

How important are:

- Leadership skills in your work now?
- Project management skills in your work now?

Comparing these variables enable us to comment on how engineering alumni perceive the undergraduate curriculum to prepare them for the workplace.

Limitations

The purpose of the larger study from which data are drawn was to develop an understanding of the national landscape of undergraduate engineering education and of the development of a set of learning outcomes deemed important by the National Academy of Engineering. To provide this portrait, the research team compromised on precision of direct measurements in favor of a survey format that would enhance generalizability of findings. [42] Additionally, the study sample does not represent all engineering disciplines; however, the seven disciplines represented produce about 70% of all U.S. engineering baccalaureate degrees.

One criticism of survey-based measures of learning outcomes is that they are self-reported rather than derived from more objective measures, such as direct observations (see, for example, [43]). Most studies of self-reported data, however, indicate a moderate to strong correspondence between self-reports and more objective measures, especially under conditions similar to those present in this study. These conditions include: 1) the information requested is known to the respondents; 2) the questions are phrased clearly and unambiguously; 3) the questions refer to recent activities; 4) the respondents think the questions merit a serious and thoughtful response; and 5) answering the questions does not threaten, embarrass, or violate the privacy of the respondent or encourage the respondent to answer in socially desirable rather than in truthful ways (as summarized by [44; 45]).

Results and Discussion

Analyses of survey responses first focused on general perceptions of leadership-related topics across faculty and administrators. A comparison of mean responses in Table 4 shows that there is disagreement between faculty and administrators regarding the degree to which professional skill teaching degrades technical content. While tenure track faculty tend to agree that professional skills development takes away from technical content, non-tenure track faculty, program chairs, and associate deans tend to disagree. Among faculty, an analysis of variance with a Bonferroni post-hoc analysis showed that non-tenure track faculty had a statistically significant difference from the tenure track faculty at the $\alpha=0.05$ level. Additionally, assistant professors and full professors differed significantly. One potential explanation for the differing perceptions of non-tenure and tenure track faculty could be the competing requirements of the tenure process. Because greater emphasis is typically placed on technical research and scholarship than teaching at many institutions, additional emphasis on professional skills could detract from already scarce technical content preparation time. For those focused on achieving tenure, emphasis is best placed in the areas aligned with institutional goals. Additionally, non-tenure track faculty may be better aligned with industry needs and thus find it more important to emphasize professional skills. In general, the further faculty and administrators remove themselves from the classroom, (progression from faculty to program chairs to associate deans), the less professional skills are perceived as taking away from technical content. Program Chairs and Associate Deans may be more likely to interact with industry representatives and read reports such as *The Engineer of 2020* and are hence more likely to align with their findings. This would also explain the closer alignment of non-tenure track faculty to Program Chairs and Associate Deans as compared to their tenure track or tenured colleagues.

Table 4. Descriptive statistics of leadership perceptions across higher education faculty and administrators. Means are shown for each variable with standard deviations in parentheses.

Survey Question	**Non-Tenure**	**Asst. Prof.**	**Assoc. Prof.**	**Full Prof.**	**Faculty Overall**	**Pro. Chair**	**Assoc. Deans**
Emphasizing professional skills takes time away from teaching technical content.[a]	3.25 (1.0)	2.81 (.87)	2.93 (.97)	3.00 (.99)	2.97 (.97)	3.11 (.87)	3.39 (.80)
Students' leadership skills are best developed in extra curricular activities.[a]	2.94 (.96)	2.58 (.88)	2.62 (.77)	2.70 (.87)	2.68 (.87)	2.94 (.86)	2.73 (.92)
The undergraduate engineering curriculum should prepare students to assume community leadership roles.[b]	3.55 (.83)	3.51 (.85)	3.51 (.86)	3.43 (.89)	3.48 (.86)	3.83 (.85)	3.77 (.86)

[a] 5-point scale, where 1=Strongly agree, 2=Agree, 3=Neither agree nor disagree, 4=Disagree, 5=Strongly disagree
[b] 5-point scale, where 1=Strongly disagree, 2=Disagree, 3=Neither agree nor disagree, 4=Agree, 5=Strongly agree

Mean responses to the question about extracurricular activity show a general consensus among faculty and administrators that leadership skills are best developed in extracurricular activities. Again, ANOVA indicated that non-tenure track faculty showed a statistically significant difference at the $\alpha=0.05$ level among all faculty types, but they still tended to agree slightly. The reviewed literature indicates a general lack of clarity regarding leadership topics among engineering faculty members. This lack of clarity could explain why faculty and administrators are willing to entrust leader development to extracurricular experiences. In addition, respondents may have the perception that the technical curriculum does not have enough room to include leader development, thereby relegating its development to the extracurriculum.

These findings seem inconsistent with the notion across faculty and administrators that the engineering curriculum should prepare students to assume community leadership roles. Faculty and administrators showed highest agreement that the engineering curriculum should prepare students for community leadership roles, a finding consistent with the recommendations of the National Academy of Engineering[3]. Only assistant professors and full professors showed significantly different perceptions at the $\alpha=0.05$ level. This consensus is somewhat paradoxical. Although faculty and administrators acknowledge the need to prepare undergraduate students to be community leaders, as previously mentioned, they also tend to agree that the classroom is not the best place to develop students as leaders. These findings present a perception that faculty and administrators lack ownership of leader development of undergraduate engineering. Thus, faculty and administrators tend to concur with the National Academy's call for technically competent leaders[3], but may be unwilling to affect this call within the engineering curriculum.

To gain deeper understanding of pervasiveness of leadership perceptions among faculty and administrators, a by-discipline analysis was conducted. Table 5 shows the general lack of consensus as to the degree to which professional skills detract from technical content across engineering disciplines. Within this analysis, ANOVA indicated that Program Chairs and Associate Deans showed no significant differences. Mechanical engineering faculty differed significantly from bioengineering/biomedical, civil, industrial, and electrical engineering at the α=0.05 level. The overall stronger agreement among mechanical engineers seems to suggest a more technically minded mechanical engineering discipline from other disciplines within this study. If one considers the nature of bioengineering/biomedical, civil, and industrial engineering, the difference is not as surprising. Biomedical/bioengineering and industrial engineering place an emphasis on human related factors, providing logical correlation to an increased perception of the importance of professional skills. For civil engineering, leadership is part of the ABET program curricular criteria[6], and hence would logically have greater emphasis in the civil engineering curriculum, although the civil engineering faculty also tended to agree. The difference between mechanical and electrical engineering is somewhat harder to explain and could be the focus of future research.

Table 5. Discipline specific statistics of professional skills emphasis. Means are shown for each variable with standard deviations in parentheses.

Emphasizing professional skills takes time away from teaching technical content.[a]	**Faculty**	**Program Chair**	**Associate Deans**
Biomedical or Bioengineering	3.28 (.85)	3.20 (.83)	4.0 (N/A[b])
Chemical Engineering	2.96 (.95)	3.44 (.78)	3.5 (.71)
Civil Engineering	3.06 (.86)	2.96 (.81)	3.0 (0)
Electrical Engineering	3.00 (.98)	2.82 (1.01)	3.83 (.98)
General Engineering/Engineering Science	3.03 (1.05)	3.00 (N/A)	
Industrial Engineering	3.16 (1.05)	2.90 (.74)	3.67 (.58)
Mechanical Engineering	2.75 (.82)	3.38 (.89)	3.25 (.96)
Other Engineering discipline	2.91 (1.0)	3.25 (.96)	3.00 (.82)
Total	2.97 (.97)	3.11 (.87)	3.39 (.80)

[a] 5-point scale, where 1=Strongly agree, 2=agree, 3=Neither agree nor disagree, 4=Disagree, 5=Strongly Disagree
[b] Standard deviations of (N/A) indicate a single data point.

Table 6 shows general consensus among disciplines that leadership is best left to the extracurricular experience of undergraduate engineering students, with minor exceptions. ANOVA showed that chemical engineering faculty differed significantly from civil, industrial, and electrical engineering, mechanical, and other disciplines at the α=0.05 level. We observed no significant difference across disciplines among Program Chairs and Associate Deans. This general impression of leader development best performed outside the engineering classroom is consistent with the reviewed literature indicating a lack of clarity among faculty regarding the concepts of leadership and a historical tendency for leader development to be the subject of non-engineering disciplines. Our analysis indicates that this perception is pervasive across the engineering disciplines.

Table 6. Discipline specific statistics of extracurricular leadership development. Means are shown for each variable with standard deviations in parentheses.

Students' leadership skills are best developed in extra curricular activities.[a]	**Faculty**	**Program Chair**	**Associate Deans**
Biomedical or Bioengineering	2.99 (.80)	3.44 (.52)	4.0 (N/A[b])
Chemical Engineering	3.06 (.89)	3.22 (.73)	3.5 (.71)
Civil Engineering	2.62 (.92)	2.75 (.77)	2.33 (.58)
Electrical Engineering	2.64 (.90)	3.06 (1.03)	2.67 (1.03)
General Engineering/Engineering Science	2.89 (.87)	3.00 (N/A)	
Industrial Engineering	2.63 (.82)	2.57 (.83)	2.67 (.58)
Mechanical Engineering	2.55 (.77)	2.95 (.97)	2.5 (1.29)
Other Engineering discipline	2.57 (.73)	2.75 (.50)	2.71 (.95)
Total	2.68 (.87)	2.94 (.86)	2.73 (.92)

[a] 5-point scale, where 1=Strongly agree, 2=agree, 3=Neither agree nor disagree, 4=Disagree, 5=Strongly Disagree
[b] Standard deviations of (N/A) indicate a single data point.

Table 7 shows a by-discipline breakdown of perceptions regarding curricular requirements for developing community leaders. ANOVA indicated that mechanical engineering faculty differed significantly from civil, general, and industrial engineering at the α=0.05 level. In addition, civil engineering faculty differed significantly from chemical and electrical engineering at the α=0.05 level. Program Chairs and Associate Deans showed no significant difference. The generally greater agreement of civil engineers to this statement is not surprising because of the ABET leadership outcome for civil engineering programs [6]. Additionally, the lower agreement among mechanical engineering faculty corroborates the notion that mechanical engineers are more technically focused than other engineering disciplines, although in this case, even mechanical engineers concur that they should be developing community leaders.

Table 7. Discipline specific statistics of community leader preparation perceptions. Means are shown for each variable with standard deviations in parentheses.

The undergraduate engineering curriculum should prepare students to assume community leadership roles.[a]	**Faculty**	**Program Chair**	**Associate Deans**
Biomedical or Bioengineering	3.57 (.82)	4.37 (1.09)	3.0 (N/A[b])
Chemical Engineering	3.41 (.82)	3.57 (.88)	4.5 (.71)
Civil Engineering	3.79 (.80)	4.14 (.59)	4.00 (.00)
Electrical Engineering	3.37 (.92)	3.53 (1.01)	3.00 (1.10)
General Engineering/Engineering Science	3.69 (1.04)	3.00 (N/A)	
Industrial Engineering	3.74 (.84)	3.70 (1.06)	3.33 (.577)
Mechanical Engineering	3.28 (.71)	3.83 (.69)	4.25 (.50)
Other Engineering discipline	3.61 (.82)	4.25 (.50)	4.14 (.69)
Total	3.48 (.86)	3.83 (.85)	3.77 (.86)

[a] 5-point scale, where 1=Strongly disagree, 2=Disagree, 3=Neither agree nor disagree, 4=Agree, 5=Strongly Agree
[b] Standard deviations of (N/A) indicate a single data point.

We also explored the degree of emphasis placed on leadership and closely related project management skills within engineering programs. Table 8 shows a general consensus between students, alumni, non-tenure track faculty, and program chairs on the moderate-to-strong emphasis placed on leadership and management skills within the undergraduate curriculum. These values differ from the curricular emphasis reported by tenure track faculty (only a slight-to-moderate emphasis). These findings are consistent with previously mentioned perceptions that professional skills take away from technical content among tenure track faculty.

Table 8. Descriptive statistics of alumni, faculty, and program chairs on leadership curricular emphasis. Means are shown for each variable with standard deviations in parentheses.

	Students	**Alumni**	**Non-Tenure**	**Asst. Prof.**	**Assoc. Prof.**	**Full Prof.**	**Faculty Overall**	**Prog. Chair**
Course/program emphasis: Leadership skills. [a]	3.33 (1.02)	3.27 (.97)	3.37 (1.04)	2.57 (1.29)	2.58 (1.13)	2.77 (1.25)	2.75 (1.23)	3.56 (.80)
Course/program emphasis: Project management skills.[a]	3.32 (1.06)	2.84 (1.10)	3.11 (1.20)	2.33 (1.37)	2.46 (1.23)	2.60 (1.36)	2.57 (1.33)	3.40 (.96)
Importance of leadership skills in your work now[b]		4.14 (.87)						
Importance of project management skills in your work now[b]		4.11 (1.03)						

[a] 5-point scale, where 1=Little/No Emphasis, 2=Slight, 3=Moderate, 4=Strong, 5=Very Strong

[b] 5-point scale, where 1=Little/None, 2=Slight, 3=Moderate, 4=High, 5=Very High

Quite concerning, this level of emphasis on leadership in engineering programs differs greatly from the high importance alumni perceive for both leadership and management skills within their first three years of practice in industry (Table 8). These results from alumni suggest that the current engineering curriculum might not be supporting the needs of recent graduates within their first three years of practice with respect to leadership. These findings also contradict the general consensus among faculty and administrators that they have a requirement to create community leaders. It seems some emphasis exists, but there is still much room for improvement in order to meet workplace demands. Such findings are consistent with the small number of institutions that have developed leadership programs for undergraduate engineering students. On more than one occasion, a lack of alumni success in industry advancement was cited as a driving force in the creation of these leadership development programs.

To further investigate leadership and project management emphasis in courses, we exampled whether or not a faculty member's experience in industry work experience related to their course emphases. As shown in Table 9, we observed a statistically significant correlation between faculty's affiliation with industry while employed as faculty and their emphasis on leadership and management skills. Work experience prior to faculty employment did not statistically relate to course emphases. If one equates years of working with industry as an indicator of alignment with industry while employed as faculty, these data are intuitive. Those faculty who work more closely with industry can be viewed as more responsive to *current* needs of industry, such as leadership and project management skills, and appear to carry that recognition into their classes.

Table 9. Correlation examination of faculty work experience to leadership and project management emphasis. Pearson correlation coefficients are shown for each variable with significance in parentheses.

	Years working in industry: While employed as full-time faculty	**Years working in industry: Before employed as full-time faculty**
Course emphasis: Leadership skills	.24 (.00)	-.51 (.54)
Course emphasis: Project management skills	.25 (.00)	-.03 (.70)

No statistically significant correlations between race/gender and leadership/project management emphasis.

Conclusions and Recommendations for Future Work

This study expands the scope of previous, qualitative works regarding faculty perceptions of leadership in the engineering curriculum using a nationwide sample. Consistent with the reviewed literature, these nationwide data show that faculty and administrators acknowledge a requirement to prepare students to be societal leaders. In general, there is disagreement as to the degree to which professional skills detract from technical content coverage, however, and there is a general consensus that leadership skills should be taught through extracurricular experiences. While mechanical engineering tended to be more technically focused than the other engineering disciplines, we found few differences between engineering disciplines in these perceptions. Thus, perceptions appear to be pervasive and not limited to any specific subsets of faculty of administrators. Additionally, the current engineering curriculum is not emphasizing leadership or project management skills at the same level as required by newly graduated alumni within their

first three years in industry. Faculty more closely aligned with industry understand this dynamic and are emphasizing those skills more than their colleagues with less industry experience.
This study has significant implications for engineering education practice. Because of the misalignment between leadership and project management skills emphasis during and after the undergraduate experience, increased faculty emphasis on leadership and project management skills within the curriculum seems warranted. Purposeful incorporation of leadership and project management skills into engineering curriculum is a logical next step as alumni indicate its importance in practice and both faculty and administrators acknowledge the requirement for the engineering curriculum to develop community leaders. Implementing this change will require a change in perception among faculty and administrators as to where leadership is best affected within the undergraduate experience. Greater coordination between curricular and extracurricular planners is warranted to ensure adequate coverage of leadership and management skills within the university experience if leader development is left to the extracurriculum.

The correlation between faculty's industry experience and leadership and project management course emphases should be viewed as a mark of success and expanded. These data indicate that better coordination between higher education and professional practice actors (more than just industry) is warranted to ensure alignment of leadership and management practices between the classroom and those implemented in practice. Industry and community leaders can influence the development of leadership programs through additional coordination with institutions of higher education. This coordination should be highly contextualized to ensure leadership development is tailored toward industry and societal experiences into which an institution's graduates typically matriculate. Industry can further influence students' leadership development by providing financial resources to universities to support purposeful leader development programs for undergraduate engineering students.

Future research should focus on more purposeful study of undergraduate students and alumni to better understand what facets of the engineering curriculum and extracurriculum most impacts and develops leadership and management skills. Additionally, more detailed study of undergraduate engineering student leadership situations is warranted to contextualize the experience and provide a more coherent theoretical framework. Finally, a better understanding of why tenure track faculty, Program Chairs, and Associate Deans differ in perceptions of leadership within the engineering curriculum is warranted. This overall increased understanding will better inform faculty and administrator decisions on the most effective use of limited resources toward effective leader development strategies for undergraduate engineering students to better meet industry and societal needs.

References

1. President's Council of Advisors on Science and Technology. (2012). Report to the President: Engage To Excel: Producing One Million Additional College Graduates With Degrees In Science, Technology, Engineering, and Mathematics. In. (Washington D.C.
2. American Society for Engineering Education. (2009). Creating a Culture for Scholarly and Systemic Innovation in Engineering Education. In. (Washington D.C., American Society of Engineering Education.

3. National Academy of Engineering. (2004). The Engineer of 2020: Visions of Engineering in the New Century. In. (Washington D.C.
4. American Society for Engineering Education. (2012). Innovation With Impact: Creating a Culture for Scholarly and Systematic Innovation in Engineering Education. In. (Washington D.C., American Society for Engineering Education), p 77.
5. STEM Development Office. (2009). STEM Education and Outreach Strategic Plan. In, D.o. Defense, ed. (Washington D.C., Department of Defense), p 13.
6. ABET. (2012). 2013-2014 Criteria For Accrediting Engineering Programs. In. (Baltimore, ABET.
7. Farr, J.V., and Brazil, D.M. (2009). Leadership Skills Development for Engineers. Engineering Management Journal 21, 3-8.
8. Committee on Science Engineering Public Policy, and Committee on Prospering in the Global Economy of the 21st Century. (2007). Rising above the gathering storm: energizing and employing America for a brighter economic future.(Washington, D.C: National Academies Press).
9. Shuman, L.J., Besterfield-Sacre, M., and Mcgourty, J. (2005). The ABET “Professional Skills” – Can They Be Taught? Can They Be Assessed? Journal of Engineering Education, 41-55.
10. Russell, J., and Yao, J.T.P. (1996). Consensus! Students Need More Management Education. Journal of Management in Engineering—ASCE 12, 17-29.
11. Gerhart, A., Carpenter, D., Grunow, M., and Hayes, K. (2010). Development Of A Leadership And Entrepreneurship Skills Assessment Instrument. In American Society for Engineering Education Annual Conference and Exposition. (Louisville, KY, American Society for Engineering Education), p 21.
12. Terenzini, P.T., and Reason, R.D. (2005, November). Parsing the first-year of college: A conceptual framework for studying college impacts. In Annual Conference of the Association for the Study of Higher Education. (Philidelphia, PA, Association for the Study of Higher Education.
13. Terenzini, P.T., and Reason, R.D. (2010, June). Toward a more comprehensive understanding of college effects on student learning. In Annual Conference of the Consortium of Higher Education Researchers (CHER). (Oslo, Norway, Consortium of Higher Education Researchers.
14. Schuhmann, R.J. (2010). Engineering Leadership Education--The Search for Definition and a Curricular Approach. Journal of STEM Education: Innovations and Research 11, 61-69.
15. Cox, M.F., Cekic, O., and Adams, S.G. (2010). Developing Leadership Skills of Undergraduate Engineering Students: Perspectives from engineering faculty. Journal of STEM Education: Innovations & Research 11, 22-33.
16. Bowman, B.A., and Farr, J.V. (2000). Embedding Leadership In Civil Engineering Education. Journal Of Professional Issues In Engineering Education And Practice, 16-20.
17. Natishan, M.E., Schmidt, L.C., and Mead, P. (2000). Student Focus Group Results on Student Team Performance Issues. Journal of Engineering Education July, 269-272.
18. Williams, J.M., Ahmed, J., Hanson, J.H., Peffers, S.N., and Sexton, S.M. (2012). The Rose-Hulman Institute Of Technology Leadership Advancement Program: Preparing Engineer-Ing, Math, And Science Students For Leadership Success. In ASEE Annual Conference and Exposition. (San Antonio, TX, American Society for Engineering Education.

19. Bayless, D.J., Mitchell, J., and Robe, T.R. (2009). Engineering Leadership Studies And The Robe Leadership Institute Model In The Russ College Of Engineering And Technology At Ohio University. In 39th ASEE/IEEE Frontiers in Education Conference. (San Antonio, IEEE), pp 1-6.
20. AlSagheer, A., and Al-Sagheer, A. (2011). Faculty's Perceptions of Teaching Ethics and Leadership in Engineering Education. Journal of International Education Research 7, 55-66.
21. Farr, J.V., Walesh, S.G., and Forsythe, G.B. (1997). Leadership development for engineering managers. Journal Of Management In Engineering 13, 38-41.
22. Stogdill, R.M. (1974). Handbook of Leadership: A survey of the Literature.(New York: Free Press).
23. Yukl, G.A. (2006). Leadership in organizations.(Upper Saddle River, NJ: Pearson/Prentice Hall).
24. Hill, S.E.K. (2013). Team Leadership. In Leadership: Theory and Practice, P.G. Northouse, ed. (Los Angeles, Sage Publications Inc.), pp 287-319.
25. Salas, E., Stagl, K.C., Burke, C.S., and Goodwin, G.F. (2007). Fostering Team Effectiveness in Organizations: Toward an Integrative Theoretical Framework. Nebraska Symposium on Motivation 52, 185-243.
26. Borrego, M., Karlin, J., McNair, L.D., and Beddoes, K. (2013). Team Effectiveness Theory from Industrial and Organizational Psychology Applied to Engineering Student Project Teams—A Review. Journal of Engineering Education 102, 472-512.
27. Borrego, M., Douglas, E.P., and Amelink, C.T. (2009). Quantitative, Qualitative, and Mixed Research Methods in Engineering Education. Journal of Engineering Education, 53-66.
28. Pascarella, E.T., and Terenzini, P.T. (1991). How college affects students: Findings and insights from twenty years of research.(San Francisco, CA: Jossey-Bass).
29. Pascarella, E.T., and Terenzini, P.T. (2005). How college affects students. Vol. 2: A third decade of research.(San Francisco, CA: Jossey Bass).
30. Reason, R.D., Cox, B.E., Lutovsky-Quaye, B.R., and Terenzini, P.T. (2010). Individual and institutional factors that encourage faculty to promote student encounters with difference in first-year courses. Review of Higher Education 33, 391-414.
31. Reason, R.D., Terenzini, P.T., and Domingo, R.J. (2006). First things first: Developing academic competence in the first year of college. Research in Higher Education 47, 149-175.
32. Reason, R.D., Terenzini, P.T., and Domingo, R.J. (2007). Developing social and personal competence in the first year of college. Review of Higher Education 30, 271-299.
33. Lattuca, L.R., Terenzini, P.T., and Volkwein, J.F. (2006). Engineering change: A study of the impact of EC2000. In. (Baltimore, MD, ABET.
34. Porter, S.R., and Umbach, P.D. (2001, June). What works best? Collecting alumni data with multiple technologies. In Annual Meeting of the Association for Institutional Research. (Long Beach, CA, Association for Institutional Research.
35. Baruch, Y. (1999). Response rate in academic studies—A comparative analysis. Human Relations 52, 421-438.
36. Porter, S.R., and Umbach, P.D. (2006). Student survey response rates across institutions: Why do they vary? . Research in Higher Education 47, 229-247.

37. Van Horn, P.S., Green, K.E., and Martinussen, M. (2009). Survey response rates and survey administration in counseling and clinical psychology: A meta-analysis. Educational and Psychological Measurement 69, 389-403.
38. Kalton, G. (1983). Introduction to survey sampling (Newbury Park, CA: Sage).
39. Cox, B.E., McIntosh, K.L., Reason, R.D., and Terenzini, P.T. (2010). When doing the "right" thing feels wrong: A primer and example of missing data imputation. In Annual Conference of the Association for the Study of Higher Education. (Indianapolis, IN, Association for the Study of Higher Education.
40. Dempster, A.P., Laird, N.M., and Rubin, D.B. (1977). Maximum likelihood from incomplete data via the EM algorithm. Journal of the Royal Statistical Society B, 1-38.
41. Graham, J.W. (2009). Missing data: Making it work in the real world. Annual Review of Psychology 60, 549-576.
42. McGrath, J.E., Martin, J., and Kulka, R.A. (1982). Judgment calls in research.(Beverly Hills: Sage Publications).
43. Porter, S. (2011). Do college student surveys have any validity? . The Review of Higher Education 35, 45-76.
44. Hayek, J.C., Carini, R.M., O'Day, P.T., and Kuh, G.D. (2001). Triumph or tragedy: Comparing student engagement levels of members of Greek-letter organizations and other students. Journal of College Student Development 43, 643-663.
45. Kuh, G.D. (2005). Imagine asking the client: Using student and alumni surveys for accountability in higher education. . In In Achieving accountability in higher education: Balancing public, academic, and market demands, J.C.B. Associates, ed. (San Francisco, Jossey-Bass), pp 148-172.